7th Symposium on Frequency Standards and Metrology Summary Submission for Oral Presentation

Cesium Fountain Primary Frequency Standards at NIST

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The U.S. primary frequency standard, NIST-F1, has been regularly contributing to TAI for almost 9 years and currently has the smallest uncertainty of any fountain contributing to international atomic time (TAI). We will discuss the current state of NIST-F1, along with improvements and challenges which allow its systematic uncertainty to regularly reach $\delta f/f = 3\times10^{-16}$. The uncertainty is dominated by the uncertainty in the blackbody correction, $\delta f/f = 2.8\times10^{-16}$. Typical uncertainties in the spin-exchange frequency shift (considered as a Type A uncertainty in NIST-F1) are at the level $\delta f/f = 1\times10^{-16}$, removing this as a significant source of uncertainty. Since the previous symposium in 2001, we have developed the theory of microwave induced frequency shifts in pulsed standards including power dependences in the distributed cavity phase shift, the effects of leakage and spurs, both incoherent and coherent. These effects play a significant role in the uncertainties of most fountain standards. We will report our techniques designed to lessen these effects. In NIST-F1 microwave effects are currently held to the $\delta f/f \le 1\times10^{-16}$ level with the uncertainty dominated by measurement statistics.

Because the uncertainty in the blackbody shift correction dominates in our room-temperature standard, we are developing a new fountain standard (imaginatively named NIST-F2) in which the Ramsey interaction region is cooled by conduction from a liquid nitrogen dewar to about 80K. This reduces the magnitude of the blackbody shift from the $\delta f/f \approx 10^{-14}$ level at room temperature to $\delta f/f \approx 10^{-16}$ level at 80K with the result that the uncertainty of NIST-F2 should be limited by microwave effects and the spin-exchange frequency shift. We have recently finished assembly of NIST-F2 and hope to present preliminary results of a blackbody frequency shift measurement at the symposium.